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EDITED BY

W. C. EBAUGH

Permanent Secretary Denison Scientific Association

GRANVILLE, OHIO

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The entire file of volumes 1 to 13 was destroyed by fire; no publications issued prior to 1907 are now available. Volumes 14 to date may be obtained from the editor at $2.00 per volume, with the exception of volume 15, the price of which is $1.00. Separate parts, as listed below, may be purchased at the prices indicated.

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W. C. EBAUGH

VOLUME XXII

1927

GRANVILLE, OHIO

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DENISON SCIENTIFIC ASSOCIATION

Organized April 16, 1887

REPORT OF THE PERMANENT SECRETARY FOR THE YEAR 1926–1927

The following officers served the Association during the current year.

FRANK J. WRIGHT, *President*
(Miss) MATTIE L. TIPPETT, *Vice-President*
DONALD R. FITCH, *Secretary*
RICHARD H. HOWE, *Treasurer*
M. E. STICKNEY, *Librarian*
W. C. EBAUGH, *Permanent Secretary and Editor*

The usual public meetings and lectures were supplemented by a special series of addresses delivered at the exercises commemorating the fortieth anniversary of the founding of the Association. The speakers and their topics are presented herewith.

September

SMOKELESS SOFT COAL—THE GOAL OF THE FUEL ENGINEER—W. C. EBAUGH

October

ELECTRON ORBITS—C. D. COONS

November

CAN WE TEACH RELIGION?—F. W. STEWART
STATUS OF THE QUESTION OF WAR RESPONSIBILITY—W. M. GEWEHR
ISLAND UNIVERSES—PAUL BIEFELD

December

THE CALCULUS—WHAT IS IT?—F. B. WILEY

January

INTELLIGENCE TESTS—T. A. LEWIS

February

AFTER FREE VERSE—WHAT?—C. H. DICKERMAN

WHAT IS AN ENGINEERING EDUCATION?—B. D. GREENSHIELDS

March

TRANSLATION AS AN ART—AUGUST ODEBRECHT

THE EVOLUTION OF THE LIBRARY—MARY E. DOWNEY

April

SCIENCE AND RELIGION—ROBERT A. MILLIKAN

SCIENCE AND LIVING—C. JUDSON HERRICK

FOUNDING OF THE DENISON SCIENTIFIC ASSOCIATION—ALFRED D. COLE

FORTY YEARS OF SCIENTIFIC THOUGHT CONCERNING THE ORIGIN OF LIFE—KIRTLEY F. MATHER

DARWIN AS A PIONEER IN EVOLUTION—GEORGE A. DORSEY

May

IS THE HUMAN SPECIES CHANGING?—A. W. LINDSEY

ALASKA—R. H. SARGENT

Invitations (figs. 1 and 2) to attend the fortieth anniversary of the founding of the Denison Scientific Association were sent to past and present members of the Association, educational and scientific institutions, scientists, friends and officers of Denison University and to a selected list of persons interested in the Association and its work.

Large audiences greeted the speakers at all sessions. The presence of the student body of Denison University at the meetings held at 11.30 a.m. on three Wednesdays in April, in Swasey Chapel, gave an opportunity for our youth to come into contact with science as interpreted by men of eminence in their respective fields. The outcome was assuredly most pleasing.

When assembled at the Granville Inn for the Anniversary Dinner felicitations were offered by representatives of various Ohio colleges, universities and scientific organizations, thus making the occasion one of more than merely local importance. Reminiscences of the early days of the Association, as given by

Dr. C. Judson Herrick, a younger brother of the founder, Clarence Luther Herrick, and by Mrs. Clarence Luther Herrick made the humble beginnings of the Association very real.

The Presbyterian Church was kindly offered to the Association for the Commemoration Addresses, as the work of renovating the Baptist Church edifice was not quite completed. Dr. Frank Carney, a former Permanent Secretary of the Association and a valued contributor to the *Bulletin,* was prevented from speaking by reason of pressing business engagements that demanded his presence in a distant part of the United States.

It is not often that a small denominational college of the Denison type supports a scientific association and publishes a worthy journal in the field of science for forty years or more. That the record of the fortieth anniversary of the founding of the Denison Scientific Association may be made available in permanent form to the large circle of the Association's friends is the reason for issuing the present special number of the *Bulletin.* The addresses reported in it were prepared from stenographic notes, but copy was not revised by any of the speakers concerned.

Respectfully submitted

W. C. EBAUGH, *Permanent Secretary*

The Denison Scientific Association

invites you to attend

exercises commemorating the

Fortieth Anniversary of its Founding

Tuesday, April 19, 1927

at

Denison University

Granville, Ohio

FIG. 1

Program

GENERAL ADDRESSES

Swasey Chapel, 11:30 A.M.

WEDNESDAY, APRIL 13TH

ROBERT A. MILLIKAN, PH.D.

Director Norman Bridge Laboratory
California Institute of Technology

SCIENCE AND RELIGION

WEDNESDAY, APRIL 20TH

KIRTLEY F. MATHER, PH.D.

Associate Professor of Physiography
Harvard University

FORTY YEARS OF SCIENTIFIC THOUGHT CONCERNING THE ORIGIN OF LIFE

WEDNESDAY, APRIL 27TH

GEORGE A. DORSEY, PH.D.

Author, New York City

CHARLES DARWIN, A PIONEER IN EXPERIMENTAL EVOLUTION

Anniversary Program

TUESDAY, APRIL 19TH

ANNIVERSARY DINNER, Granville Inn. 6:00 P.M

Reminiscences of Early Days

COMMEMORATION ADDRESSES, Baptist Church, 8:15 P.M.

C. JUDSON HERRICK, PH.D.

Professor of Neurology, University of Chicago

FRANK CARNEY, PH.D.

Consulting Geologist, National Refining Company

ALFRED D. COLE, A.M.

Professor of Physics, Ohio State University

FIG. 2

SCIENCE AND RELIGION

ROBERT A. MILLIKAN

(An address delivered April 13, 1927)

I have a son who is a member of the Liberal Club of Harvard, and a short time ago he wrote me saying that he had his doubts about the legitimacy of a man's using a scientific reputation for getting an audience in a field in which he had no competence. I replied "Guilty, thrice guilty of having come out of the hole in which I have burrowed for most of my lifetime for the sake of seeing what the world looks like, instead of telephoning to the Liberal Club and having them tell me what it looks like."

However, I do not know that I would have dared to speak on a subject of this kind before an audience like this had not President Angell, of Yale University, asked me last fall to deliver what are called the Terry Lectures at New Haven. The Terry Lectures were founded for the sake of getting a man of science, or a student of philosophy, to present from his point of view the effect of the growth of his subject upon philosophy and religion. I hesitated about accepting such a task for much the same reason my boy had indicated in his letter to me—that I had no competence to speak upon such a subject—but, and this I want to emphasize to you young men and women, every one of us cannot help integrating his experience into some kind of a philosophy and some kind of a religion. Everybody does it. He cannot help doing it. Nor can any inquiring groper after truth, and none of us is anything more than a groper, fail to tell a fellow-inquiring groper how things look to him when asked. And that is all I am trying to do in this very brief fashion. I cannot possibly do the theme justice in the time of your chapel hour, and in order that you may not have any misconception as to my point of view I will refer you to the Terry Lectures, recently published by Yale University Press, if you want to have it stated with more care, perhaps, than I can tell it in this kind of an extempore address.

I want to start by calling attention again to a fact that is brought to your mind all the time, *viz.*, that we are living in an age in which we are making very, very rapid changes in our points of view and in our control over nature. You young men and women, and we men who have grown a little older, have the fortune or misfortune, whichever you want to call it, of living in a generation when the world is changing more rapidly than it did in any other generation or ten generations together. The reason it is changing, I suppose, we physicists must take largely upon our own shoulders. It is because of the changes in science primarily, changes in the physical sciences carrying with them changes in our whole view-point of life. We are learning more about the physical world in which we live and we are learning it faster than we have ever learned it heretofore.

In the midst of these changes it is worth while to reflect that most of us act most of the time, all of us a part of the time, and some of us all the time, purely conventionally. So has it been with mankind throughout the ages. We do the things which our neighbors around us do. We talk piously about law enforcement and the constitution, as members of the Better America Federation, and forget all about law enforcement when it becomes customary in our social group to violate speed laws, dodge taxes or support boot-leggers. Most of us are Republicans or Democrats because our fathers and mothers were Republicans or Democrats. We are Baptists, Congregationalists, Catholics or Mohammedans because our fathers bore those brands. It is worth remembering that this is the case—that you, young men and women, if born in Mohammedan countries would probably be Mohammedans now. And yet the reflective morality, as distinguished from conventional morality, is obviously the only criterion of character, absolutely the only criterion, the *sine quo non* of all progress. There must be reflection about what our relations to this world are and the obligations imposed upon us by existence in it.

Gilbert Murray, a wonderfully sweet character, as Christlike a man as I have ever met, was asked last summer what he thought about the Scopes trial. For the American press he wrote this verdict: "I consider it the greatest set-back to civilization in all

history. That is my considered opinion concerning the Scopes trial." I think that he would not differ with me in changing his phrasing a little bit. I think that what he meant to say was that if the suppression of thought and the return essentially in all particulars (save those of physical violence) to the method and spirit of the inquisition were to be successful in the United States it would be the greatest set-back to civilization in all history. And I thoroughly agree with him myself. But I am not so much concerned about the Scopes trial because I do not think that the effort behind it is either very successful now, or is likely to be successful. Indeed I should go farther and say that I presume that the Scopes trial, and all the newspaper publicity that went with it, have been among the big educative influences of our generation. Why? Because it has set a lot of people, thousands of people, millions of people, who have never done so before, to *thinking* about the basis of their own religious conceptions. And if it has done that then it has been one of the stimuli to progress rather than something that suppresses progress.

We are living in an age of very great change. We are living in a period in which we are evolving in our knowledge of the physical world. We are evolving in our history. We are evolving in our knowledge of the biological world. In other words the keynote of our modern world is growth or evolution. And now I am about to say something that may be thought heretical, but it is something which is taught in every theological seminary of every denomination in the United States, *viz.*, that our religion as we find it today is one of the best possible examples of evolution. I would like to run over with you four stages in the evolution of religion, as I see it.

First, primitive religion. One does not need to be an anthropologist, nor to have made profound studies about primitive races, in order to see that primitive man's religion was a very crude thing. One does not need to do anything but be a little familiar with the Bible to find out that that was the case. We can learn something about what primitive man thought from the fact that a great many primitive peoples are living today, just as there are many survivals of early biological forms. Primitive man, just

coming into the age in which he reflects a little for himself instead of acting wholly as the animals do—instinctively—finds himself surrounded by powerful enemies who kill and enslave him, and to whom, when they are more powerful than he is himself, he has to give up the very best he has—perhaps his daughter or his son—in order to make possible a cannibal feast. At the same time he finds himself surrounded by forces of nature which seem to him to be as capricious and cruel to him as are his enemies. He is struck down by a thunderbolt. He is wasted with disease. He dies from hunger. What does he do under these circumstances? Probably the only thing that man in that stage of development could do; he begins to personify nature. He sees a spirit, Pan, in the wood, a nymph in the stream, and everything he does not understand he attributes to the caprices of these beings with which he has peopled the earth. When his need is very great he begins to sacrifice to these beings, his gods or his god (if he is a monotheist), and in cases of dire distress he does just what he would do before a powerful earthly enemy—he sacrifices the best he has. He gives up his son or daughter to propitiate his god or gods. Human sacrifice was practiced by practically all primitive peoples, at least by all that lived in the Mediterranean area. You find it in Greece first when Iphigenia, daughter of Agamemnon, had to give up her life to propitiate the gods' anger when the Greeks turned the prows of their ship toward Troy. You find it in Phoenicia when the children of loving parents were thrown into the burning, fiery furnace as a sacrifice to Moloch. And you find it in Palestine where, according to Bible story, Abraham started to offer up his son, Isaac.

Now notice the next stage in the evolution of religion. Somebody arises somewhere, somehow, who begins to do a little thinking for himself. Unlike his neighbors he begins to ask if his god is just or a cruel, vengeful brute like the king of an adjacent tribe, a being who can be propitiated by the sacrifice of an only son. And in the Bible story it was Abraham who began to raise these questions in his own mind and then, as a result of his own reflection, answer them. Then and there be broke with the past and started a new era. The Bible says "God spoke to Abraham." How did

he speak? Through some Arab sheik who just then happened to pass that way? In that case it would have been the Sheik, and not God, speaking to Abraham. Through a voice that would have left a record on a phonograph concealed in the bushes? You smile. Why? Because who wants such childish interpretations? Or was it through the still, small voice of reflection that God spoke?

But even so, where did that idea come from that got into Abraham's mind? Where do our ideas come from? I do not know. All we know is that somehow we are here, created, in the Bible phrase, "out of the dust of the earth." Somehow there has developed here a mind which begins to think for itself, to exercise intelligence, to make choices. There is no miracle in the world comparable to that—the thought that we exist, that we know that we are here and that sometimes great conceptions, new ideas leading on to better things, spring up in the minds of men. God spoke to Abraham. I do not know of any better way in which modern science could put it; in that olden day there was no other way in which it could have been said. God spoke to Abraham.

God spoke to Lycurgus when he ordered human sacrifices stopped in Sparta, and only a little time later Abraham had them stopped in Palestine. Abraham and Lycurgus were very much alike in that neither of them could do anything more than just take a faltering first step away from their older conceptions. Abraham thought that God was not a being who could be propitiated by the sacrifice of an only son on the part of a father, but he imagined that he was a being who could be pleased with the sacrifice of a sheep or a goat in place of the son. In other words, God would take delight in burnt incense and the suffering of animals. Lycurgus did not go quite so far as Abraham. When Lycurgus abolished human sacrifices in Sparta he substituted for it the flogging of young men and women, still thinking that God could be propitiated by human suffering. All over the Mediterranean area a whole group of religions grew up based on that idea, and animal sacrifices were a part of the religion of Jews, Greeks, Romans and other nations. With the abolition of human sacrifices the first step is passed in what I look upon as the evolution of religion.

Before we go farther let me make a definition, for nine-tenths of all our discussions arise because we do not have our definitions so that we understand one another. What is religion, as I am using the word? There are two elements in all religion. Historically I find but two. One is some conception about the nature of what it is behind the multifarious phenomena of nature, giving unity and significance to the whole thing. In a single word, some conception of God. Then, too, there must be some conception of duty. The latter conception grows right out of the former, for the conception of what the world means and what God means will naturally carry with it the conception of one's relation and responsibility to the world and to God. Those two words, God and duty, underlie all religion. Watch how those conceptions of God and Duty change with the growth in man's knowledge of the world in which he lives.

Now you are ready for the next stage in the evolution of religion. Thousands of years have passed since the first stage. People have lived, for the most part, conventional lives. They have done what their neighbors around them have done—tithed, brought the firstborn of their sheep and oxen to be sacrificed and thus sought propitiation. Then another divine event occurs, divine in exactly the same sense as was the last. A new idea comes into human thought and pushes the world upward to a higher plane of thinking, living and feeling. That new idea came in a limited way through Mohammed, in a much fuller way through Buddha, and in a great, big, swelling tide through Jesus—a new conception of God and a new conception of Duty.

Jesus struck the most mortal blow that has ever been struck at all childish literalisms and all that underlies what we call modern fundamentalism when he said "It hath been written—".Where? In His bible and in ours. "But *I* say unto you—."He wanted to show us something bigger, something finer than had ever before been written. Thus we have Jesus' words when he said "The kingdom of Heaven is within you," "God is not a man; God is a Spirit, and they that worship him must worship him in spirit and in truth." For the first time in the history of the Jews Jesus conceived as the basis of this universe not a man, but a great benevo-

lence. His gospel was simply the gospel of a God of Love. For the first time in the history of the Jews he had a conception of God which transcended the confines of Israelism and Judaism, and which saw that Benevolence extending over all the world, to all races and to all countries.

During the fifteen hundred years of terrible strife and bloodshed through which the world went after Jesus' time that conception and the beautiful life and teachings of Jesus became the basis of our whole western religion, in so far as Christianity is concerned. But let us be perfectly honest; let us not forget the backward steps religion took during those fifteen hundred years, for it did take backward steps. Jesus had tried to impress upon his disciples, with all the energy he possessed, that his kingdom was not an earthly kingdom and that it did not rest upon a sign. He refused to allow his disciples to build it upon a sign. He called their attention away from these caprices of nature. Of course his followers could scarcely be expected to have risen to his heights, and in the next fifteen hundred years the whole beauty of his life, and the religion that developed from it, became encrusted with superstition. There were the miracles of the church—all kinds of efforts to do precisely the thing which Jesus said must not be done, i.e., build his kingdom upon a sign.

At about the close of the fifteen hundred year period another divine event occurred, divine in just the same sense as the last. A new and higher conception of God and duty began to come into human life and thought and spread throughout the world. I can not attach that to any particular name, but it came about the time of the renaissance in Italy; if you want to link it up to any particular name I would perhaps suggest that of Galileo. Perhaps he was responsible—as much as any one man—for introducing the scientific mode of thought to life, for giving a new idea concerning the world and for presenting a new conception of God and the way in which he works.

Galileo had been taught the old Aristotelian theory about the relation of force and motion. He began to question the old teaching in just the same way that Abraham did in another field, asking whether the things that had come down from the past were ade-

quate for the conditions of the world he saw. And that is how he came to go up the leaning tower of Pisa to make his famous experiment with two blocks, one of metal and one of wood, to see whether the velocities imparted to them would be proportional to the force acting upon them, as Aristotle had thought. According to this teaching the heavier body would fall faster than the lighter. But he found that the two bodies struck the earth at the same time, and again a group of ideas that had existed for thousands of years could be entertained no longer. Galileo, however, was a constructive as well as a destructive critic. He was not content merely to destroy the old; what he did was to set a task for himself and to spend a life-time of effort to see whether he could replace the old conception by new and better conceptions. As a result he arrived at the idea which is contained in what we now call Newton's Second Law of Motion, or "force equals the mass times the acceleration." That idea has exerted a larger influence upon the destinies of the human race than perhaps any other idea that has entered the mind of man. I say this not because it underlies our modern material civilization—the whole thing would collapse like a house afire and we would go back to the old conditions existing in Rome and Greece were we without it—but because the scientific method of approach to the world's problems began just about that time to change our philosophy, our thinking and our religion. It put our religion upon a finer, broader basis than ever before.

As a consequence of Galileo's experiments nature, for the first time in history, began to be something that was orderly. It was a nature capable of being known, a nature that had infinite forces or powers within it, if we could only understand it, capable of being utilized for the enrichment of life and the progress of the race. That idea was new, absolutely new. In a single word, at that time there was spread throughout the world the idea of a God who works through Law. How much finer a conception of deity that is than any that had preceded it can be seen from a comparison of the second element of religion, the conception of duty. Think of the monasteries filled with those who did nothing except retire and commune with their own souls; compare that condition

with the ceaseless activity of a Kelvin, a Pasteur or a Maxwell trying to find out the springs of nature's behavior and then apply them to the enrichment of life, the amelioration of suffering and the building of a finer civilization! Our whole religion is changed. Nobody nowadays goes off into a monastery to commune with his soul, for there is a bigger job on hand. Thus our conceptions of God and of duty have changed through the introduction of the scientific mode of approach or mode of thinking about the world in which we live. This is the third state in the evolution of religion.

By following the method of Galileo for two or three hundred years we come to the fourth stage in the evolution of religion, the stage in which we are now living. A new group of ideas comes into human life. It has come through the application of Galileo's method to the study of geology, which has shown us a world, this earth of ours, that has grown through millions and millions of years. It has come through the study of biology and comparative anatomy, where we have found evidence indicating the continuous growth or development of organisms. It has come through the study of human history, where we can see how human or social institutions have developed and we have gained more and more control over our environment, replacing the old slave-supported civilizations by the first civilization in the history of the world that has ever succeeded without the support of slave labor. It is the idea of progress, an idea that was entirely foreign to ancient thinking. You do not find a trace of it in your study of Greek or Latin. It is a new idea, a contribution of modern science to religion, to our conception of God and how he works, and to our conception of duty. It is the most stimulating conception that has ever been evolved; it is the very basis of modern religion. The keynote of most of the churches of today is "service." Thus modern science has given approval to the ideas which Jesus introduced into the world. Jesus felt a benevolence throughout the universe. Modern science gives evidences for its belief in the possibilities of continual growth toward higher and better things.

It is true that our conceptions change somewhat as time goes on. What we are trying to follow is the change in our concep-

tions with the increase of knowledge as to the way in which nature behaves. In this process of change you will find, of course, crowds that hang behind and cannot break away from the traditions of the past. You will find other crowds that want to break away completely and say that all religion is a lie. The first calls itself Fundamentalist; it clings to the past, incapable of changing. The other calls itself Atheist; it calls out "Away with the past! Away with all the past!" To neither of these two groups has the idea of growth or evolution ever come. They do not see what this evolutionary process really is. They do not see the satisfaction there is in being part of a movement toward better things, toward a finer society. That motive has become the keynote of religion, the ideal of service. If our churches can keep in tune with the progress of modern times they will be, as they have been been in the past, the biggest elements in our progress. But if they can not do that they are just as certain to be swept aside into the back-wash of human progress, and other institutions that can do the work that they were put here to do will be found to take their places.

The prophet Micah said more than two thousand years ago "What doth the Lord require of thee, but to do justly, and to love mercy, and to walk humbly with thy God?" "To do justly and to love mercy" give our relations to our fellow-beings; "to walk humbly with thy God" is what modern science has been learning to do in the last forty years. Forty years ago modern physics thought that it saw it all. It has found so much that it did not comprehend in the least, so much that it never dreamed of as a part of physics forty years ago, we have ceased to be as dogmatic in physics as we used to be. And modern science is contributing something to religion if it teaches religion to walk humbly with the Lord, its God.

FORTY YEARS OF SCIENTIFIC THOUGHT CONCERNING THE ORIGIN OF LIFE

KIRTLEY F. MATHER

(An address delivered April 20, 1927)

I need not express my real pleasure at being here and standing on this platform once more. I am especially gratified to be speaking to you in honor of the 40th anniversary of the founding of the Denison Scientific Association. It was a rare privilege for me to be associated with that organization during my years as a member of the faculty here. If there is any one thing for which Denison is famous in the scientific world, outside of the State of Ohio, it is the Scientific Association and its publication, the JOURNAL. Wherever I have gone I have found men who knew nothing concerning Denison except the fact that Denison publishes a scientific journal of very high merit. I count that one of the fine things which Denison is doing for the world at large, and I am especially pleased therefore to speak on such an occasion as this.

During the forty years of life of the Denison Scientific Association scientists have made great progress in their task of discovering the nature of the world in which we live. Some of the results of those forty years of patient observation and investigation have been a little bit startling to men. Our feeling of importance, may I say our conceit, has been seriously undermined. The astronomers have told us that the earth is just an ordinary planet of no special significance whatsoever. That it is neither the largest nor the smallest, the hottest nor the coldest, the swiftest moving nor the slowest moving, among the planets which are the family belonging to our sun. They have told us that the sun upon which we depend for energy, for very light itself, is no important star, just one of many, many in the great galaxy of the heavens, and the sun is not a very hot nor a very cold star; there are many hotter and many bigger, and many others that are smaller. It is just an ordinary star.

As we recoil from the verdict of astronomy that the earth is just a speck in the midst of far-flung space, we wonder what it is that makes the earth seem so important, and we geologists have paralleled that account of astronomy by our discoveries that today in the history of the earth is no important day, but just one of many days in the endless flow of time. Before man came upon the earth the earth was here and the days were then just as they are now. When man has run his brief course, has had his day and ceases to be, perhaps the earth will continue right along in the same old way. But even more startling than that geology tells us now that before ever the earth was in existence as a planet depending upon the sun that same star, our sun, had an earlier generation of planets in its train and after this family has been abolished, smashed to smithereens as some day a half-billion years hence, more or less, it will be smashed, another generation of planets will gradually develop from the nebula thus formed. Today is no important day. The succession of planetary systems come and go; we are in the midst of an endless cycle of events.

If there is anything at all to give significance to the earth it is the fact that you and I are here upon it. Except for that one fact the earth is but a speck of foam upon the crest of a wave in the midst of the Pacific ocean, just for an instant hovering there and then lost in oblivion. But for that instant this little speck of dust, old mother earth, has prime importance for you and me. We are here upon it, we therefore consider with considerable interest the problem which you and I present to the world and to ourselves. Why are we here? And where do we come from? And how did we get here?—the age-old questions asked thousands of years ago and still unanswered, to be queried again thousands of years hence, and presumably still unanswered then.

Just one of those questions can take our time now, *viz.*, the question pertaining to the origin of life upon the earth itself. All of us know perfectly well that today life comes only from life. We are convinced,—science has done that for us,—that every living creature, plant or animal, upon the face of the earth today is the off-spring of some other living creature or creatures. "Life only from life" is a rule of the universe so far as we can tell.

And yet the record of the rocks indicates unmistakably that as we trace life backward along the road we find that the assemblage becomes smaller, more compact, that the widest limits within the group are much closer together the farther back we go. The convergence of living creatures backward in time is a fact indisputable today. You may draw whatever inference you care to from that fact; the fact remains. Most of us draw the inference that life came into existence upon the earth in far off geological ages as a very simple one-celled plant-animal, at least as lowly as the lowliest form of life in existence today. Those existing lowliest creatures are truly "plant-hyphen-animal" that combines the qualities, capacities and attributes of these two kingdoms. Most of you would say, off hand, that it is the easiest thing in the world to distinguish a plant from an animal, to distinguish between these two great kingdoms. A broad gulf seems to be fixed, but the facts are quite otherwise. There are living today creatures that truly bridge the gap between those two kingdoms. They are rather common creatures found wide-spread in many ponds, marshes and swamps, but so very tiny that they may be easily overlooked. Those little creatures have green chlorophyll within their bodies. By virtue of the presence of green chlorophyll they may utilize the energy of the sunlight to manufacture food for themselves. That is the attribute that distinguishes all of the green plants. They can make food from mineral substances which were not previously food. Animals have not that capacity. They are all parasites. Every animal depends for food upon some other animal or some plant because animals can utilize only food already prepared for them as a complex carbohydrate or a bit of protein. These are substances made in advance for the animals. Hence animals have not the ability to manufacture food, but merely the ability to digest food. And these lowly one-celled plant-animals have that capacity. Their bodies may be observed to move out to surround a bit of food, to digest it, to secure nourishment from it, and then eject the waste products. The capacities of animals are indicated there. The theoretical beginning of life upon the face of the earth must have been at least as lowly as these lowliest of creatures now in existence.

Where did they come from? Well, of course, you do not see those animals originating from any inorganic, non-living bit of mineral substance. Spontaneous generation of living creatures is no longer within the bounds of expectation. There was a day, which ended just about forty years ago, when the Denison Scientific Association was being organized, when men speculated concerning the origin of the maggots in a bit of decaying meat, and of the scorpions found cringing between two moist slabs of stone in the ground. They wondered how these living creatures might have come from non-living origins. But since the day of Pasteur we know that these living creatures have been hatched from eggs or have grown from primitive cells, that they are themselves the offspring of the previously existing forms of life.

Nevertheless, there is only one reasonable speculation concerning the origin of life itself upon the earth. As we trace our record backward we come out of the glare of the noontide of science into the ever increasing dimness of the earlier portions of the road, until finally we are lost in the blackness of night before the dawn of the first record of life upon the earth. The oldest known rocks contain no fossils whatever. The oldest known fossils are not a record of the introduction of life upon the earth; the oldest known fossils indicate creatures that are fairly well advanced from that theoretical one-celled plant-animal. Thus unhampered by facts we are free to speculate to our heart's content. But speculation is distinctly desirable. Sometimes we hear the statement that science is just the amassing of facts, the description of what is. That is only the beginnings of science. True science is not confined to the description of facts or to the amassing of data. The real problem in science is to explain the facts, and the moment that you begin to explain facts you must speculate. In very truth the bolder science has been in her speculation the more successful she has been in her achievements. The great advancements of science in making the material universe more favorable for human life have largely resulted from bold speculations concerning the origin of things, concerning how matter and energy were transformed through successive stages until they came into the form which now see them display. Speculation is distinctly desirable.

Sometimes we are told that the origin of life, in fact life itself, is a mystery, and through that man cannot hope to penetrate the veil. But again I would caution you. The mystery of life is no greater than the mystery of anything else in the world around about us. Electro-magnetic impulses and operations are no less mysterious than living impulses and living operations. The mystery of gravity is no less than the mystery of life. Or, if you do not agree with me concerning that, you surely would all agree when I assert that the mystery of the origin of life upon the face of the earth is no greater than the mystery of the origin of any single individual today upon the face of the earth. The mystery of the long processes of evolution and of development are no deeper, and no more obscure than the mystery of the growth of the individual from the beginning cell to the adult complexity of the organisms. We cannot stop because we are told that something is mysterious; that is, indeed, a challenge to us all. And the more mysterious the thing is the more intriguing the thing becomes, the more anxious we are to penetrate, if only a little, within the veil which keeps the mystery still unsolved.

Thus as we try to consider the mystery of the origin of life, we might first of all note what are the facts that need to be explained, and those facts I would call to your attention under three main headings, or in three categories. Some of the facts are chemical. We ask the chemist to tell us of what sort of stuff our living creatures come, and the chemist analyzes the tissues of the plant or of an animal and he tells us that the material of which living creatures are made are just ordinary common everyday elements. There are a half a dozen of them, more or less, carbon, hydrogen, oxygen, nitrogen, potassium, and sulphur. These are ordinary elements. They are found in nature outside of living nature. They were known long before they were discovered in living tissues because they were recognized in minerals and in rocks themselves. They are known to be present not only upon the face of the earth but also in other bodies, as revealed by the telescope and spectroscope. It is of ordinary stuff that the living creatures are made.

The second group of facts is in the category which we put under

the sway of the physicists. Living creatures have definite physical form. They have physical attributes. Among them are those capacities which I have already cited before you. Living creatures can take food or manufacture food and by virtue of it they may grow. Living creatures can reproduce themselves. These are the only real distinctions between the living and the non-living. There are non-living bits of matter which have motion closely imitating the motions of living matter. But no non-living substance can grow, can take food and utilize it, or can reproduce itself. These physical capacities must be explained as we try to consider the origin of life. But these are only a part of our problem.

There is a third category of facts also. We find that life expresses itself on various levels of its existence and when we consider the origin of life we must consider the attributes of life as displayed on its highest level. Those are the qualities which we see in human beings around about us, the fact that man looks upon the world and says, "There is a beautiful scene." "This is splendid, glorious." Man is an aesthetic animal and these qualities which we call aesthetic are a part of life. Man is a creature who knows the difference between right and wrong. He is a moral and ethical being. The ethical qualities are a part of life. Man is a being who has high aspirations, heights toward which he would attain, depths below which, or into which, he will not sink. These are the spiritual qualities, a part of the nature of life because they are a part of the nature of man. They, therefore, must also be explained as we try to consider the origin of life. The chemistry and physics are much simpler, much easier to consider than the ethics, aesthetics and psychics which pertain to life. Let us consider them, therefore, first.

Ofttimes we are led to the conclusion that life originated in the sea. But I want to present a different alternative for your consideration just now. Life, with its known chemistry and its known physical attributes, represents concentrated matter, complex to the extreme, and also concentrated energy, equal, if not superior in its complexity, to the complexity of matter. The energy as well as the matter are both concentrated in every living

cell. We should look, therefore, for an environment which would favor concentration, the gathering together, the building up of progressively more complex links in the chain rather than an environment which would spread broadcast, dilute, and disseminate matter and energy. The favorable environment seems to be not the ocean but the ground. Think back through the history of the earth to its juvenile stages when it was still a young planet, receiving many more meteorites or shooting stars from outer space than will come to it this year or next.

These particles of matter which fall through the atmosphere gleam for an instant and then are burned in space, or strike the surface of the earth. These are but samples of the stuff of which the earth is made. In them we find strange complex nitrates, phosphates, nitrite substances which spontaneously decompose in the atmosphere of the earth, and as they decompose new chemicals are found and energy is frequently liberated. Those in the outer skin of the earth were for a long time dust particles, a granular outer layer of the growing earth. If you need, as of course you do, both oxygen and water for the synthesis of a living cell, you can have them in any desired ratio in the ground. If more water is needed, go down deeper toward the ground-water level, that zone in which all the pores are filled with water. If less water and more oxygen is desirable, move up and out toward the surface, where the ground is drier. Here in the slow but rather constant flow of the trickling drops of water in the ground you have a desirable circulatory system, well designed to bring various chemical compounds in solution to the place where they are needed. Here in the ground is not only the necessary chemical substance, but also the desirable method or mechanism for bringing together the needed ingredients as the chemical synthesis goes forward.

Here also is a suggestion as to a form for that first living cell. The cell wall is perhaps just an imitation of the mineral walls around an open space in the ground, occupied by a bit of colloidal, jelly-like substance, immensely complicated in its internal structure, gradually approximating protoplasm in its make-up and form. Thus we would speculate as to how the living could have come from the non-living. From the dust of the ground the sub-

stances were taken to make that first living cell. But life is something more than just matter. It is also energy, energy of an unknown and possibly unknowable nature. We call it vital energy, but that term, vital energy, like so many of our scientific terms, is intended not so much to reveal our knowledge as to conceal our ignorance. We name it and having named it we are more or less satisfied although still we do not understand what it really is. All too often it is apparently the business of us students to get names for things, and we pride ourselves upon our broad vocabulary or glib use of names. What behooves it all if we learn the names of things and know not their nature? It is to discover the nature rather than the name of a thing to which we are challenged. The nature of vital energy is still unknown, but we can understand something about it from its manifestations. The only way we can learn anything about energy is to see how energy behaves, to discover what it does. "By their fruits ye shall know them." It is perfectly true in science as well as in the ethical realm. So the nature of vital energy is in part disclosed by the results of its presence in the living creatures, and so, for example, we discover that man is a curious sort of being, of mixed nature, of the earth, earthy; but also of the heavenly, divine. He has his moments when he acts like a beast, when his animal instincts hold domination over him. But he has his other moments when he acts like a god, when he rises supreme over those animal instincts, when he aspires to something higher than the plane on which the beasts live. I think those patriarchs of olden times who are responsible for the creation stories of our Bible caught something of the significance of all that when they reported that man was made of the dust of the ground and that he had also the breath of life, or the breath of God. They were simply stating in the vivid picturesque imaginative language of the Orient, the fact that man is a mixed being of a dual nature. That fact is one of the everlasting truths which make those ancient documents worth while, even for you and me today. So we must consider something of the possible origin of that vital energy whose nature we only partially understand.

Here there seem to be two alternatives. One of them assumes

that there is in existence such a thing as vital energy, a reality and some special form of energy different from any other kind of energy; that that vital energy has always been in existence, and that on the earth yesterday it found an opportunity to express itself. It therefore was implanted in that living cell and made it a *living* cell rather than just a bit of colloidal chemistry. That is one alternative; it leads obviously to the philosophy of vitalism. The other alternative is just as logical. To me it seems a little bit more logical, although I would not hold a brief for it as opposed to the other. Vital energy may be a synthesis of previously existing forms of energy. As shown in carbohydrates, just carbon, hydrogen, oxygen and other elements were brought together, combined, and by virtue of their new relations were the stuff of which living matter is composed. So energy, radiant energy from the sun, energy of radio activity, of electro-magnetism, of chemical action, of what-not—any kind of energy you happen to know anything about—these perhaps came together and by virtue of their new associations were enlarged and elevated into that which we now call vital energy. Thus the energy itself is a synthesis of previously existing forms of energy. I know of no way to choose with certainty between those two alternatives; either is a logical and satisfactory scientific explanation.

But what do they mean to you and me as we face the problems of life today? Where is your Creator under such a view of the origin of life as this? Have you relegated God to the background until you have pushed him clear out of existence? I think not. It seems to me that whatever theory we hold, we must conclude that energy here is itself creative. The science of today, largely as a result of the progress of the last two decades, is absolutely sure that the ultimate reality is not the matter which we see around about us, but is energy, and that energy is creative in its nature. Creative of planets and of stars, of crystals and of cells, of plants and of animals, of beasts and of men; that this energy is characterized in no other way so truly as when we call it creative energy. That creative energy is the something which pervades and permeates and fills and thrills the universe. It is the something which makes us alive and gives us our spiritual qualities.

The creative energy must be at least as great as that which it creates. The consequence cannot be greater than the antecedents. Very commonly science in this modern age reveals the fact that certain things that we evaluated as fine, high, and noble have come from origins which we think to be lowly, mean and trivial. Even some of our most sacred and cherished ideals and doctrines have come from tribal customs, from the strivings of primitive human beings. Many of our Christian customs, Easter and Christmas for example, have just as pagan an origin, just as profane an origin as they have sacred an origin. They have come from things which we would rate as mean and lowly. Faced by such facts as these many people have said, "Well, if that be true, then I made a mistake when I evaluated this as so fine, and noble, and high. It has come from the dirt itself and must therefore be dirty."

But that is only one of the two alternatives which face us when such facts as these are borne in upon our minds. The other alternative is just as true and logical. Some people say "Well, so I have made a mistake. That which I had evaluated as mean and lowly had in it the potentialities of this which I know to be fine and high. I, therefore, stoop down and pick up that which I had discarded as lowly, and I lift it to the plane of the fine and high." Creative energy, back in that dim creative process when life was coming into existence upon the earth, had the potentialities of the finest human being at its highest moment, and perhaps even greater potentialities than that. What right have we to assume that creative energy in man is displaying itself completely? Had we estimated creative energy ten geological periods ago our estimate would have been far inferior to that which we have today. Could we estimate ten geological periods ahead in all probability that estimate would far exceed the most optimistic estimate of today. We do not yet know more than a small part of the potentialities in creative energy. We must, therefore, give it its due tribute. Today we must bow the knee. Here is a power operating in the world which we know, a power whose possibilities of perfection are still undreamed. Thus it is that the scientist, as he surveys the record of the past and considers the facts of the

present, comes to a feeling of real humility. He is awestruck as he contemplates the problems of life and as he considers the immensity of the power which pervades the world and expresses itself all too partially and incompletely in humankind. To that creative energy we must therefore give wonderful tribute. It may be that our final conclusions will indicate a gradual synthetic attainment of progressively higher levels. That seems to be the trend of thought. Whether we find it false or true we cannot now tell with certainty. But still we know that the creative energy is best represented by ourselves in our finest moments.

"Two things," the wise man said, "fill me with awe;
The starry heavens and the moral law."
Nay, add another wonder to thy roll,—
The living marvel of the human soul!

Born in the dust and cradled in the dark,
It feels the fire of an immortal spark,
And learns to read, with patient, searching eyes,
The splendid secret of the unconscious skies.

For God thought Light before he spoke the word;
The darkness understood not, though it heard;
But man looks up to where the planets swim,
And thinks God's thoughts of glory after Him."

DARWIN AS A PIONEER IN EVOLUTION

GEORGE A. DORSEY

(An address delivered April 27, 1927)

Gentlemen: May I say how much I feel honored in being privileged to join in your celebration of the founding of the Scientific Association of Denison University?

I have some forty or forty-five minutes in which to attempt to account for the evolution of a great personality, a man who did more, I think, to change the history of human thought than any one who has lived in the last fifteen or eighteen hundred years. In this attempt I can't do everything, but I shall hope to do two things: (1) in tracing the evolution of Darwin's personality to give you some idea of what science these days conceives a personality to be; how we come by our character, how we get into the ways which are our individual and particular ways; and (2) to point out how it was that Darwin acquired the particular ideas we associate with his name, and the significance of those ideas for you and me. Now that is a remarkably large order, and I haven't a very long time in which to fill it, but I think I can give you the fundamentals of those two concepts so that you can carry them forward and make applications to yourself.

How can we explain Darwin? That is the first thing we have to consider. Why is it that Darwin happened to be what we call a genius? Why is it that this man who, having reached the age of twenty was a failure in his own eyes, in the eyes of his father, in the eyes of his friends—some of them at any rate—and especially in the eyes of the faculty under which he had studied? Why is it that this man, who was such a colossal failure and who lived thereafter practically the life of an invalid, was able to do what he did and died to be rated among the great benefactors of mankind? That is our first point. Is it a business of heredity? Was it because his parents were thus and so, and his grandparents

thus and so? Did Darwin himself have anything to do with the formation of his character? Did his parents have anything to do with the formation of his character? Or can we explain his personality and its effects in terms of germ plasm? Some of you realize, I suspect, that I have entered upon a problem that today is a live problem, about which there are two sharply contrasted opinions. One of these groups of opinion is voiced in such books as Wiggam's *New Decalogue of Science*, Madison Grant's *The Passing of the Great Race*, William McDougall's *Is America Safe for Democracy*, and East's *Mankind at the Crossroads*. Perhaps I should include Gould's work and also Stoddard's numerous works on the colored races. The opinion represented by these men is that we can only account for genius, morons and failures on the ground of germ plasm. Let me say from my point of view, and say it dogmatically, that Madison Grant, McDougall and Wiggam, have not one shred of evidence, that will stand the test in any court of biological science, on which to base their contentions. To know who Darwin's grandfather or grandmother was is to give us no information as to how Darwin came to be what he was. But if we can know, as we do know, something about his mother's interest, something about who his father was, or what was the father's attitude toward his son who threatened to be a failure, then we begin to get a little closer to an understanding of Darwin's character. I am holding to the position that any intelligent pair of parents in any part of the world, no matter what may be the color of their skin, shape of their eyes, character of their hair, can do anything with a son or daughter that they choose to do. In other words, you and I, Charles Darwin, your President, are all products of our social environment. That environment begins to bear upon us the day we are born and inside of six, eight or ten years has given us such a set of habits, habits of speech, emotional habits, habits of bodily action, that thereafter we walk, we talk, we think, we like and dislike, in terms of the things which have been hammered into us in the first six, eight, or ten years of our life.

Let us come a little closer now to Charles Darwin. His grandfather was a noted scientist. That in itself had no great influence

upon young Charles. Darwin's mother was acquainted with this grandfather, Erasmus. But notice this: Darwin's mother was no flapper. She was a very sensible woman. She was nearly thirty years old when she was married. She knew England as a traveler; she knew the society of London, she knew the great men of London, she knew the intelligence of London, and she had become profoundly interested in the world of nature. The Darwin home in Shrewsberry was famous for its flowers, famous for its pigeons, famous for its pets, and young Darwin's mother was equally famous for her love and cultivation of the flowers, birds, and pets in general.

There was a special reason why she was acquainted with the writings of that curious old philosopher poet, Erasmus Darwin, young Darwin's grandfather. Erasmus Darwin was a great pal of Darwin's mother's father, Josiah Wedgewood. That name may not mean much to you, but you are familiar with it in connection with a certain brand of English potteries, the "Wedgewood" potteries. It was Josiah Wedgewood who had founded these potteries. He was a man of intelligence and a man of the world, interested in doing certain things and in doing them well. Furthermore, Darwin's mother was a great pet of old Erasmus Darwin. She had read his curious books. Young Darwin talked about these things at her knee. He learned to love the sort of things that she loved. Find out any man or woman in this world who has done something you want to do; find out why he has done it. You must know where he got this love. Rest assured that he did not inherit it. We do not inherit love for anything, except food possibly. But we can learn to love anything. And at Mrs. Darwin's knee young Darwin loved to talk about and wonder about plants, pigeons, bugs, etc. I just can't conceive of Mrs. Darwin, when young Charlie, at the age of six, brought into the house a horned toad or a great big ugly looking bug, saying "For heaven's sake! get this out of the house!" Nothing of that sort. She didn't put her foot on this early curiosity along lines of that sort. Rather I can conceive of her saying, "Ah, let's have a look at it! Isn't it a beauty? Where did you get it? etc."

It is not surprising that the first picture we have of Darwin is that of a sweet-faced little lad kneeling at his sister's side. She was holding a flower in her hand. What was Charlie holding? A radio set? A croquet mallet? No, a whole flower-pot full of flowers. This mother died when young Darwin was eight. That was a great blow.

For fourteen years society at large did its best—and very nearly succeeded—in denying young Charles Darwin the opportunity of exploring this universe through the interests which he had learned at his mother's knee. In the first place it did its best to ruin all his interest in nature. In the second place it did its best to make a doctor out of him, and he didn't like that. And in the third place it did its best to make a preacher out of him, and he did not like that either. Finally, he found the opportunity—or the opportunity came to him—to explore the part of the world which he loved and he did explore it.

Let us look a little more closely at the two or three incidents I have just named.

Darwin was sent to a famous classical school in Shropshire, one of the best classical schools in England. Now let me use a figure of speech. Assume that young Darwin was covered with push buttons, the pushing of any one of which would start him dancing with joy, with glee, with interest and make his eyes sparkle. That school in six years never pushed a button in Darwin's body! That school came in contact with the young man's interest at no point. Did he get his kick out of life during those years in studying Latin? No! His mother had not trained him along that line. Nothing in his early training which had excited his curiosity was supplemented here. He got his kick out of life by going out in the country collecting beetles. He had already acquired such a regard for life in general that he would not kill a beetle just to collect it, but he would stand around and wait for it to die. He had patience. He would become so absorbed in what you and I call "the fool things" that one day while walking around on a wall at Shropshire, he just walked off the wall at the end. Well, commonly we do not think of such abstraction except in the case of an old college professor. We do not expect to find a boy of

ten so absorbed in a beetle that he will walk off the wall. But he had another source of gratifying these interests. He had a brother, a little older, by the name of Erasmus, and he and Ras, as he called him, took the old garden tool house, at the back of the Darwin home, and rigged it up as a chemical laboratory. There they amused themselves with all sorts of curious smelly things, and got stains on their fingers and all that sort of thing, and when Darwin's friends at school would ask him about his experiments he would tell them, of course, and so he got the nickname, "Gas."

One other thing before we leave that school. We get this from Darwin's autobiography. He had hardly entered school when he found that he had nothing that would excite these boys. You know, as boys, we all have the desire to possess something which we can bring out and exhibit to our friends and get a bit of excitement, get some glory for ourselves. But he had nothing in particular to offer, so he told what he called later a monstrous lie. He told these boys that he could tell the name of a flower by looking merely at its blossom. That is a rather curious vagary for a boy. It means he had thought a great deal of the names of plants. Remember the name of the grandfather's book—*Zoonomia*. Then he told an even more monstrous lie, as he would say. He told the boys of his school that he could produce any color primrose he pleased by simply using different waters on it. Some of the boys believed him and thought him pretty clever. He thereby gained in their eyes just exactly that which he sought—a bit of notoriety, a bit of excitement, a bit of quickened interest. The lies in themselves are not necessarily therefore to show that all of us, when we get in our particular field, can stretch a point or two. They are only interesting in showing the kind of lie that this boy told at that age.

Well, the classical school was a failure. Young Darwin reached the age of sixteen. He had read a lot including two books: *White's Natural History of Selbourne* and a book on the plants and animals on a certain locality in England, charmingly written, *Wonders of the World*. He had wondered about these wonders, and one of his favorite occupations at school was to wonder as to whether the man that wrote this book was always telling the truth.

So the classical school making no appeal to him and certainly arousing no interest, Darwin came to the age when it was necessary to do something and the father sent him up to Edinburgh to study medicine, because he himself had been at Edinburgh for a while, because Darwin's brother Ras was already at Edinburgh and because his distinguished grandfather had been at Edinburgh. Darwin went to study medicine. No one seemed to have asked him about that; it just seemed natural that he should follow in his father's footsteps and study at Edinburgh. Darwin was at Edinburgh two years. It doesn't take long to characterize what happened there. Shortly after he arrived he went into a cold, dark, clammy, classroom one morning in October and that was his first real introduction to the study of medicine. And as he wrote to his sister, Katherine, "Imagine this old fossil trying to interest us in this old classroom in the medicinal properties of rhubarb!" Shortly afterwards, this lad who had learned to love pigeons, and flowers, went into an operating room at Edinburgh. Remember that there were no anaesthetics at that time. A little girl was being operated on, and she screamed! That was more than young Darwin could stand, and he beat it out of the operating room and he never did go back into one again. Yet this boy was allowed to spend the remaining part of these two years at Edinburgh, apparently getting nothing out of it.

Nevertheless he did get something out of it. He met two or three congenial souls who loved to go out of the city into the country and wander about among the flowers and the birds. He met a negro who had been a taxidermist to a great ornithologist, and he paid this negro money to teach him how to mount birds. He went with a fisherman down the bay and out to sea for oysters. Because he was interested in oysters? Primarily because he was interested in little forms of life that came up with the oyster troughs.

Concerning the father? Well, I could say a great deal about Darwin's father. The last time he was weighed, which was several years before he died—and he did not shrink any between that time and his death—he weighed 335 pounds. This was the man that this youngster had to look up to. He was extraordi-

narily clever, shrewd, successful and very busy, and had very little time to find out what young Charlie loved and wanted to do. He never suspected, until he happened to read a letter which young Charlie had written to Katherine, that medicine was not to be young Charles Darwin's forte and vocation. Then he took him out of school. What next? Well, what could a rich Englishman at that time do with a boy who did not want to study medicine? Make a preacher of him! That was the only other gentlemanly occupation. Business of course was unthinkable. He sent him up to Cambridge. Why? Because the only way one could become a clergyman in the Church of England was to get a degree from Cambridge or Oxford. He was sent to Cambridge because Cambridge had been the family university. Universities then were different from universities now, and the English university system has always been different from our American university system. I make this statement because it might not seem so curious as otherwise it would to mention the fact that during the two and a half years he was at Cambridge he did not attend a single lecture. He had heard at Edinburgh, all the lectures he ever wanted to hear. Why is it that a lot of us never look at a textbook after we leave school? Darwin did not want to hear any more lectures; he had had enough of that sort of stuff. It did not interest him. He had his tutor, of course, as that was the system at the time. He got enough out of his tutor to make the grade. He had no trouble in doing that. He did not have to learn very much to get his degree at Cambridge. A little bit of Latin, Euclid, Palley's "Evidence," and so on—not very much—and he was ready to leave Cambridge.

Now note this rather significant fact; he was ready to leave Cambridge to take up his life work as a clergyman of the Church of England, but he was a failure in his father's eyes and he was a failure in Cambridge's eyes. Why? Because he had not been serious. He had gambled and belonged to a drinking club, called the Gourmand Club. They would go out of town five or six miles to an old inn and try out anything that had never been tried out before, in the way of eats, and when they struck a particularly tough old bird of the owl persuasion, they decided that they had

gone far enough in that direction. As was perfectly natural at that time for a young English gentleman, he went over to the New Market races, and we actually know that he went over with his tutor and they bet on the horses. In other words, he got in with a fast crowd and was what we would call today, an "all-around sport." Curious, what fate does! I use that term to signify something particularly uncertain in the social environment which stands up like a sore thumb.

Darwin took his examinations rather early in his University career, about two terms before he could get his degree. In other words, you not only had to take your examination to get your degree, but you had to spend a certain period of time in residence. So he was a student at leisure, as it were. He had heard of a certain professor at Cambridge by the name of Henslow. Henslow was one of those rare naturalists of the old days, the sort of a man who is a bit of a geologist, a bit of an entomologist, a bit of an ornithologist, etc.—a man who is interested in nature.

Darwin had heard so much about Henslow that he had come to think of him as an ideal but he only came in contact with him by chance. And then Henslow saw at once that here was a boy extraordinarily interested in the same things that interested Henslow. Within a few months Darwin had acquired a new nickname, *viz.*, "the man who walked with Henslow." And no one walked with Henslow as Darwin did without becoming a bigger, a broader, a greater man. Henslow himself was a clergyman of the Church of England. He was a marvelous man and inspired students to do things. As a matter of fact the following generation of naturalists in England was made up largely of Henslow's pupils. Darwin not only walked with Henslow, but went into Henslow's house; he was received as a member of the family, went down to the fens with him, and went out to sea with him. At last Darwin took his degree and went home. What for? Automatically to become a clergyman of the Church of England. But shortly before he left Cambridge, Henslow had introduced him to an old professor of geology there, Professor Sedgewick, and Darwin rather liked Sedgewick so far as the geol-

ogy hammer and the pecking of rock was concerned. Sedgewick persuaded him to spend a summer in geological study over in Wales, so young Darwin went to Wales, spent some happy weeks there and started home a little before the first day of September. Why? Because the first day of September opens the grouse shooting season in England, and no English gentlemen could conceivably let the first of September go by without getting into his shooting togs and going out for grouse. Young Charles stopped his summer excursion, got back home about the end of August and found a letter from Henslow, reading something like this:

"The British admiralty is about to send a ship, called the *Beagle*, on a two years voyage around the world to make certain chronometrical measurements. The Captain will allow a naturalist to accompany the ship, if the naturalist will pay his expenses." That was an extraordinary opportunity for a naturalist. It would seem that Henslow himself wanted to go and would have gone, as we know from letters, if his wife's face had not taken on a pained expression as he talked it over. There must have been pained looks before this. Other pained looks had got results and she knew what to do with a pained look and when to produce it. So Henslow abandoned the idea at once.

Darwin had not only read the books that I have already named, but he had become tremendously excited at Cambridge in reading Humboldt's "Personal Narrative," one of the books of the world at that time, one of the classics of travel. He talked to Henslow about it and had written to merchants "down to London" to see how he could get to these foreign countries. All of that was part of the background in Henslow's mind. So he wrote "down to London" recommending Darwin and wrote a letter to Darwin, too. There was no false modesty here—"You are the man for this trip. Just consider yourself as having started." Of course Darwin was crazy to make the trip. Who wouldn't be? If you don't mind my being personal I may be permitted to tell you a little of my own experience, for I know just how he felt. I too read one of these great travel books, when I was a boy here in this town of Granville, got greatly excited about it, and decided that I was going to see something of this earth. While I was still a graduate

student at Harvard, Professor Putnam called me in one day and asked me where I wanted to go, and I said I wanted to follow in Darwin's footsteps. And I went down to South America and spent two years there.

What did Papa Darwin think about it? What did this domineering 335-pound man think about it? This is funny, but it is very serious, because we all have a father. (Mine is present today, and I am very fond of him!) This father said, "Charlie you can't go." Charles was a very dutiful son. I can't even think of his saying: "Why?" But his father continued "I'll tell you the reason why. This trip won't help you preach. You have been a waster up at Cambridge. You have been a card player; you have been a bird catcher. Now this trip won't help you. It will cost you some money and it won't help you on your way at all." So Charles, like a dutiful son, wrote to Henslow saying, "I am sorry but I cannot go." We don't know what he thought that night; I suspect that what he thought could not be printed—at any rate it is not printed. But he got up the next morning, packed his kit bag and started over to Morrow, the old home of his Uncle Josiah Wedgewood, of his grandfather Josiah Wedgewood, and of his mother's family. These Wedgewoods were pretty nice people. He talked it over with Uncle Josiah and Uncle Josiah saw the point at once. Here was a marvelous opportunity. Suppose Uncle Josiah had got immensely excited about this boy's lamentable failure up to this time and had let his emotional excitement die out there. (A lot of us get excited about things, but we don't do anything to get rid of the thing which excites us.) But Uncle Josiah wrote a note and followed it up with a drive of thirty miles across the country to talk with Darwin's father. "Why not take a chance? You say this boy is a failure. Well, this can't hurt him. This is a naval vessel, a warship. There is discipline on it. Charles is keen to go. Henslow would not recommend him if he were not worthy. Why not take a chance with it?" The good Dr. Darwin, who had great respect for Uncle Josiah Wedgewood, consented. But note how close Darwin was to have missed sailing away on the *Beagle*.

Charles went to London. He interviewed this very young, very rich and very aristocratic captain of the *Beagle*, Captain Fitzroy, descendant of an illegimate branch of the house of Stuart. Captain Fitzroy also was one of those people—and the breed still exists—which is just smart enough to tell what a man has inside of his head by the shape of his nose. Now there was not anything the matter with Darwin's nose. But presumably a butcher boy, or somebody with a nose similar to that of Darwin, had pinched young Fitzroy when he was a youngster and had prejudiced him against people of that sort. He said "You can't go!" And Darwin again wrote home next day "Packing up. Trip's off." Fate again comes in. Fitzroy got in touch with Henslow. Henslow said, "Take another look at that nose. It is a good nose, and he is a good boy, and there isn't anything the matter with him. He is a man, one of the most helpful men in the world" Darwin had already acquired a great reputation at Cambridge, not so much for card playing but as being a gentleman when he was playing cards, as always playing the game like a thoroughbred; and I don't know anybody who is really better than an Englishman when he is really a gentleman. Fitzroy did take another look at him, another look at that nose, and Darwin sailed away on the voyage of the *Beagle*.

That voyage lasted 5 years instead of 2. The *Beagle* circumnavigated the globe. It went across the Atlantic to Brazil, on down the coast, across and up and down Patagonia, once around Terra del Fuego, on up the west coast of South America, Chile, on to the Galapagos Islands; from there over to the South Sea Islands and Australia, into the Indian Ocean, down around the Horn, over to Brazil again, in order to complete time measurements in which Captain Fitzroy was particularly interested, and back home; and Darwin had been gone from his home within two or three days of exactly 5 years.

Note this, please, because we must make a rather sharp break here. What did Darwin think about nature when he left home? Well, he thought the authority found in the first chapter of the book of Genesis as to how this earth and plants and animals came into existence was the only textbook worth credence. In other

words, he was orthodox. The world at that time was orthox. Solid Dayton, Tenn.! How could naturalists at that time account for certain things which struck them in the face? Well, they would interpret Genesis in any way they liked. For instance, the geologists were very prone to call into existence additional natural creations. The Bible spoke of only one flood but that did not mean that there might not have been two, so they created floods to order. Just so the botanists created continents to order, if they could not account for the botanical world otherwise. Darwin started his voyage and began to observe before the ship was hardly out to sea. He noted by the time he reached Brazil that species do not seem to be as sharply defined as he had thought they ought to be. It was not a case of "Here is one distinct feature, and here is another, and the two look no more alike than this." But they seemed to fade into each other by imperceptible stages.

In the second place they discovered some giant fossils, some of the great rodents. He began to compare these giant fossils with the living forms, and he saw again that they were built on the same general order. They were structurally related, morphologically related; and that caused him to wonder too.

But the great event of that trip was the Galapagos Islands. These islands, you know, stand off the coast of Colombia some 250 miles. They are new islands, new geologically, differing greatly from the land of the mainland. Darwin did not have to take more than a look at these islands to realize that he was in a new world, as it were; and he got excited about it and wrote in his journal. We can get an idea of the excitement of this young man, because he was still orthodox and fundamentalist regarding these ideas, yet he says to himself "Here I am beholding, as it were, something fresh, something new from the hand of the Creator." And he looked a little bit further and discovered birds and lizards, reptiles, flowers and so forth. They did not seem so new. They were almost like species found on the mainland; so much like them that they did not seem like new species. But they were entirely different from the forms of the mainland, and yet genetically related, or seemed to be genetically related, blood relations, to all those over on the mainland.

With ideas such as those stirring about in his head, he continued his journey. Curiously enough, on landing in England not another word was ever said by young Darwin himself, by his father, or by any other member of the family, so far as we know, as to his becoming a clergyman. In other words, he had found his work. Opportunities now opened up and he began to collect evidence, to edit his journal, to distribute the great collections which he had made on this round-the-world trip; and within a short time he had worked out a little fifteen-page sketch in which he attempted to show that species had not been created in the twinkling of an eye, as it were, by a magician; but that forces, natural forces such as you study in your chemical laboratory, such as you study in your physical laboratory, had been at work and that in the long processes of time species had evolved. Just what did Darwin do there? Let us say that Darwin took the "super" out of supernatural and turned the world of nature back to man again where it was in the dim, distant past, and gave it to man to look at, to observe with his eyes, with his ears, with his nose, etc. The fact that you are studying natural science, biological science as you are is because Darwin so presented the case for evolution that the world believed. The strides we have made in all these subjects in the last few years seem astounding.

It was not so very long ago that in one of the halls right over here to my right dear old Galusha Anderson, in trying to demonstrate Christian evidences, wiggled his thumb and said "No monkey, no ape, can do that." Now here is the idea. Suppose a monkey could; would that lessen Christianity? That point apparently never occurred to him, but it is occurring to us today and we realize that whether a monkey can wiggle his thumb or not has not anything to do with Christian behavior, with the profound lessons which Christianity teaches. Had he ever seen any monkey try to wiggle his thumb? I doubt it. What is modern science today? How has it come about? How has it come to be what it is? By using our eyes, by makng observations. I love to tell the story of how the great Jenner, when a youngster studying medicine in London under Hunter, went to Dr. Hunter and said, "What am I to think about?" He said, "Don't think.

Make some observations." Jenner went out and made some observations, and as a result you and I have survived smallpox. We inoculate, we vaccinate, and now get smallpox only in a mild form. That is all science is doing today, all it ever can do—use its eyes, its ears and its nose to make observations through the extraordinarily delicate instruments of precision found in our laboratories. Does science know all about anything? Certainly not. Is science a false Messiah? Is science trying to supplant anything? Certainly not. Science is simply honest observation, fearless observation. Trying to do what? Learn, learn a little more and a little more; revising the old concepts, revising its laws.

In all this great advance of the last 50 or 60 years we take our stand with Darwin who made it respectable to look with our eyes at anything, and come to any honest conclusion about it, without fear of church, without fear of dogmatism, without fear of anybody. And therein Darwin was a great benefactor of mankind.

SCIENCE AND LIVING

C. JUDSON HERRICK

(An address delivered April 19, 1927)

It has been written "A prophet is not without honor save in his own country." That is evidently not true of some university professors. And I appreciate very much the gracious words which have been spoken this evening, a part of which I can take home to myself, most of which I can whole-heartedly pass on to my teacher, my elder brother.

And so I come back here to my old camping ground, and tread again the soil, some of which is still pretty well worn around the Chapin spring where I camped for several summers and where I did some of the best scientific work I ever did in my life; where I cooked my breakfast over the coals in the morning and where Professor Stickney showed me how to take a cold bath in the Chapin spring.

Forty years ago this Tuesday evening we met in that little recitation room which is Professor Stickney's lecture room now, and which was then the whole of the department of geology and natural history. Professor Cole had the room across the hall, which was the whole of his department of physics and chemistry, so far as I know. The details of that meeting are a little bit hazy in my mind, but I know that I was there at the birth of this society. I was not one of the big bears but I was one of the litter of cubs that was born that night, and I have great pride in it. And as I review the forty years in which I have known the record of this association, I think of it in terms of three things.

There was a certain amount of actual instruction given; there was a certain amount of teaching done, informational work. It took the place of the Journal Clubs which I suppose are going on still in more or less intimate connection with the departmental work. It did a large service in supplementing the instructional work.

In the second place, it stimulated research on the part of the small faculty and students. We were all urged to see something that somebody else had not seen or to see for ourselves for the first time what somebody else had seen—which really was original observation just as much as if it had not been seen before by the eyes of man, because if we got it ourselves without somebody else to tell us how to get it we would be trained *how* to get it. And we young cubs in the preparatory school were taken on field trips and introduced to the scientific method, the research method, at the very beginning of our experience. The thing was worked out well; the list of charter members had names of men who have actually produced things in science, and the years that have followed have yielded many more scientific investigators who have contributed considerably to the sum total of human knowledge. There was a certain stimulation of intellectual curiosity that began in the first days, and that is the essence of scientific knowledge, as I see it.

The third thing which constitutes, in my judgment, the most important accomplishment of this association was something that those of us who have not contributed to the sum total of human knowledge, those of us who make no claim to be scientifically informed, can say that we have got—a thing that causes a very considerable proportion of the attendance upon our meetings to be drawn from the non-scientific departments of the college and student body. That is, we had a constant encouragement and stimulation of appreciation of values, of scientific values, of human values, of vital values; and that, I think, is the thing which has stood during these forty years as the most important contribution of the Denison Scientific Association to the life of this community. And it requires no technical training in science, no technical acquaintance with scientific methods, to draw this particular advantage from the work of the Denison Scientific Association, and especially from those early meetings. Scientific values need no illustration at this time and in this place. It is commonplace what scientific values are, how scientific research has increased the sum of human wealth; the economic aspect of it needs no advertisement. The Panama Canal may take some

hundreds of millions of dollars to build and we feel it is a good investment; it is a scientific product. It was possible because of advances, not only in engineering science, but in sanitary and many other branches of science.

We do not appreciate perhaps as keenly as we should that some other lines of scientific work that have no practical application have the same economic value that applied science has. We draw this distinction between practical science and the so-called pure sciences, those that seem impractical. We sometimes forget that these last are basic to the others, and the investment of hundreds of millions of dollars in sanitary work, as has been done in one of our cities in the West, was a good investment from a financial standpoint to that city. It has paid big dividends in money, but the investment of a hundred millions of that community in the fundamental researches which made the design and construction of the sanitary work possible is not appreciated, perhaps, as keenly by the tax payers as an actual investment by a city as we wish it were. The Panama Canal was possible because sanitation was possible. It was not possible before that, as the French themselves proved—not because they were not efficient engineers, but because they were not sufficiently good sanitarians. When yellow fever was conquered the canal was built. And yellow fever was conquered by obscure, unknown scientific workers whose names you never hear, some of whom gave their lives in the conquest. The obscure laboratory workers, working on impractical problems, are the ones upon whom we must base our obvious and important contributions to practical affairs in the long run. Those are the men who need support. The industries will take care of their research, in the nature of the case. As soon as an industry becomes advanced sufficiently to intelligently take care of their problems the industry will automatically take care of its research. But the basic problems upon which the industry is founded are the ones we are apt to forget. There is no longer any distinction between applied and pure sciences, but it is the so-called pure science which we need to support.

I have been talking in terms of dollars and cents, thus far. It is unnecessary to talk in those terms. But we know them, we

understand them, we appreciate them. The only point I want to stress in that connection is that a lot of so-called impractical work is worth dollars and cents and is basic to the more obviously practical work which we all recognize to be of economic signifcance. But what about the value of this work to the investigator himself, to the student. The Denison Scientific Association, has fathered some investigatons; it has fathered a great many other people who were not investigators but who appreciated these values and got something out of these values for themselves. We have, I think, all come to know more clearly than we did that appreciation itself, aesthetic or any other type, is not inconsistent with knowledge. We have certain courses in art, we have certain courses in literature, to which we encourage our students to devote themselves. Do we expect them all to be creative artists? To be great novelists, or literary men? We are training them largely in appreciation of what others have done. We train them in the technique of the art in order that they may better appreciate the art. Does that increased knowledge in the technique of the art, whether it be of music, painting, writing, or anything else whatever, does that increased knowledge of the technique of the art destroy the appreciation? On the contrary, it is essential for the fullest appreciation of the art itself. I think we all recognize that a large part of education is the training of these values and the appreciation of these values, artistic values, sentimental values, emotional values, moral values. How about the values in life—just plain honest ordinary every day living? Is it going to do us any harm to know more about the technique of living? Are we going to be any less appreciative of the finer things of life if we know something about the technique of living? Does the musician who has learned the principles of the control of his own voice become less appreciative of the beauties of music because he knows the technique? Does the biologist become less appreciative of the values of living? I have not observed it so.

How do great scientists stack up as compared with the average successful men in other lines? Have they been hurt from the standpoint of their own appreciation of values by the scientific training they have received?

I know one professor of biology who spends his summers in an Art Colony on Long Island Sound and paints; and his paintings are exhibited with those of the other members of that Colony. They are good enough to measure up to the others. He is not any the worse as a biologist for that—I am sure of that—and his paintings are good, so the artists say. I know an experimental physiologist who is a very good musician. I know one college professor who inflicts more pain on animals than any other biologist of my acquaintance. He is a vivisectionist by trade. He is as hard-boiled in the laboratory as anybody I know. He does it in exactly the same spirit that the surgeon operates on a child. It hurts him. Just as a mother operates on her child's finger when a sliver has to be pulled out. Of course it hurts, but it is better to take the sliver out than to leave it in. My friend the physiologist hurts his animals, but it is better to hurt the animal than to let the children die, and the animals themselves benefit in the long run. That vivisectionist is one of the men who inflicts as much pain on animals, as any scientist in the country, and he told me—he is a man of advanced years, now nearing the end of his active career—that it was very hard, and had been all his life, for him to keep at it. It wrings his heart; he is the most tender-hearted man of my acquaintance. His work has not brutalized him any more than it brutalizes a great surgeon to save a child's life.

I visited the greatest physiologist of Great Britain a few weeks ago. I saw his experiments on rabbits and guinea pigs. After a few hours of very pleasant talks in his laboratory he slipped into my hand a little parcel, as I went out the door. On the train I opened it—a volume of exquisite poems, delicate, sympathetic, tender, by the man whom the British Empire has honored in all ways within its power, including a knighthood, not for the war work he did, but because he was a great biologist, a great physiologist; and it was that man who wrote those tender, delicate little poems with the finest type of sentiment and sympathy that you will find anywhere.

Don't let anybody delude you into thinking that scientific training blunts the sensibilities of its devotees. It is not true. It is a libel on the whole profession. The scientific game is the most

exciting game in the world. Biological experimentation is the most exciting game on earth and for the biggest stakes. I have repeatedly said so, and I say it again; nothing less than the control of human destiny lies in our hands if we choose to use it. We do not know yet exactly how to do it. We have done some things that are pretty big with our material surroundings. The Panama Canal is not the biggest of them; perhaps we have done lots of bigger things. Perhaps since this village was founded the entire landscape has been made over; changing the entire flora and fauna of a continent—is that a small thing? It may be for better or for worse, but we have done it. We can change the fauna and the flora of Licking County, Ohio, and we have done it within a hundred years. Can we change the human fauna of Licking County, Ohio? Well, we have in less than two hundred years, completely changed it. We have bred a lot of new live stock on these farms—actually made them out of something else.

The geneticist knows what he wants and he goes out and gets it very often. Can we breed a new stock of men and women by setting out to get what we want? Maybe! If we can, is there any reason why we should not do it? Is there any reason why we should not try? We have done it to a certain extent. We have done it, usually blindly, ignorantly, stupidly. But we know, or can find out, the factors that go to make up the fiber of a human stock, that make human stock just mud or gold. We have done that last. We have done it over and over again, going out directly after a product and getting it. We know the technique of it. We can look back over the history of human progress, and we can see some of the things that have been done, perhaps blindly. Would it be better to do that thing intelligently or to go on drifting along and muddling through? Do we prefer to know how to do well our trade, that trade of living, that job of living? Or do we prefer to muddle along and let it come out as it will? It is for us to say whether we prefer to raise crops and stock on our farms as our parents did a hundred years ago, or to do it better. The principles involved are just the same. The technique involved is radically different if we are going to improve the human stock than that employed if we are going to improve live stock on our farm.

It is seventy years since Darwin, more or less. During that period the principles which Darwin tried to teach have been slowly filtering down through and outward into the more or less literate population of the world. Those principles are relatively simple. And yet how many of the otherwise intelligent people of North America really know anything about it? The principles of which we were speaking a moment ago, these more recent phases of scientific knowledge which we must know, are vastly more difficult, vastly more complicated, than the Darwin principles; and is it surprising that it filters rather slowly and that we do not understand much about it? And yet I am confident that we who are sitting here, and others like us in intellectual communities, are the arbiters of our own future and our children's future, and that our skill, our success in handling these problems depends pretty largely on the efficiency which we show (1) in grasping the fundamental rules of nature in accordance with which we must live, and then accustom ourselves to the rules of the game so that we can live a sanitary life, sane in body and in mind; and (2) in passing that on to other people, that knowledge of sane living in body and mind. Too much of that knowledge is bottled up. It does not filter out. I belonged to a literary society when I was here whose motto "Know Thyself" is a good one. To "know thyself" is certainly the foundation of a true education. Self-knowledge is the foundation of all education, the basis of all culture. We have tried to stress the point that we do not lose our appreciation of values if we know something of the technique of art; we do not lose something of the appreciation of human values if we know something of the technique of human living; we do not lose something of the appreciation of moral values if we know something of the technique of morals. We do not lose anything of self-appreciation if we know something of ourselves.

Now the knowledge of which I speak covers a pretty broad range. We must know ourselves as mechanisms. There are lots of them in the body. We have got to know how the body works, the levers in the body, the method of circulation, etc. We have got to know the troubles of ailing bodies. We get along pretty well as long as the body is well, but if the body is wrong somebody

must know the mechanism of the living body. We must know the mechanics of sanitation, how to build sanitary works. We must know something of the psychics of living, and there is a mechanism of that. I am not going into that aspect of it; I believe that could be handled biologically. We must know something of social living, of getting along with other people, the mechanisms of society, of social organizations, of relations of man to man. The mechanics of getting along with your neighbor resolves itself pretty largely into the mechanics of getting along with yourself. Get yourself in hand first and you will get along with your neighbor much better.

Now there is a mechanics to every one of those things. There is a mechanics to philanthropy and to the whole ethical framework. There is more to it than the mechanics; we can handle them scientifically. And my plea is that we do not necessarily lose any of the values by knowing the measurement of the values any more than we lose the values of music by knowing music.

There are two groups of obstructionists. There are some timid moralists who are afraid to know. A man said to me one time when we were discussing some question of liberal interpretation or something of that sort: "I am afraid to think along that line," and he refused to discuss it. His refusal to discuss the subject along that line was a very wise decision. Let him who fears to think not dare to teach. We have so much eloquent ignorance teaching that which the teacher does not know that it is time we called a halt and insist that the teacher that teaches facts know what he teaches. Eloquent ignorance has done more harm in the progress of human culture than all the materialists since the days of the early Greeks. It doesn't do any harm to know. If the thing does not bear being brought out into the light, be suspicious of it. That is one group of obstructionists—people who do not dare to think.

There is another group of obstructionists—the people who do not know how to think the thing through. There is a certain unity of nature. There are certain people who know mechanics up to a certain point; but there is one mechanics of the beast and another of birds and another of fishes and another of men, and you

cannot measure your man by the mechanism of the bird or fish. Yet there is a large group of naturalists who are trying to do just that thing. They are trying to work through a scientific mechanism, an intelligent method of living, and succeeding splendidly. After they have worked that thing into any type of mechanism with which they are perfectly familiar, which they call objective behavior, they stop and say there is nothing more, and those types which do not conform are not scientific, are not approachable by the scientific method and hence are negligible. I challenge both statements. In the first place, thay are approachable by the scientific method; and in the second place, they are not negligible. They are of moral value. And if we do not know how to approach them by the scientific method, let us find out. Let us not abandon the whole of conscious experience in all of its aspects, let us not throw it overboard because we do not know how to interpret it in terms of calories or automotive functions. Let us find out how. The thing is real; we are living it and doing it and working with it; and let us not throw it overboard ignorantly.

So that we have, I think, a limitation of effective living and of appreciation of values on two sides: the one is one I spoke of a moment ago, the side of timidity—those who are afraid to think; and the other is on the side of incompleteness—those who are unable to think their problem through. I do not say that natural history is the whole of living, but we will get long better if we know our living processes as far as we can explain it by the natural method. If we chop it off we say "there is a thought we cannot handle by the natural method and therefore we can afford to neglect it;" and that is what a considerable proportion of our scientific people are doing.

There is a very old text that I would like to come back to: "Know the truth and the truth shall make you free." That is good science!

FOUNDING OF THE DENISON SCIENTIFIC ASSOCIATION

ALFRED D. COLE

(An address delivered April 19, 1927)

The Denison Scientific Association, which tonight celebrates its Fortieth Anniversary, was extraordinarily fortunate in its birth because of its founder, Clarence Luther Herrick. He was a man of tremendous enthusiasm, and that enthusiasm was of a most contagious character.

In April, 1887, he had been on the Denison faculty a little over two years. Already he had begun the publication of the *Bulletin of the Scientific Laboratories of Denison University*, the first number of which appeared in December, 1885. I was at that time in charge of the Chemistry and Physics Department. One day he came to me with his plan for a Scientific Association. We talked it over, and he soon convinced me of its desirability and imparted some of his own enthusiasm to me. Last Saturday was the Fortieth Anniversary of the evening when quite a group of professors and students met in his recitation room in the "New Brick" and discussed plans for organizing the new Scientific Association. A constitution was adopted that night, which is preserved in full in the Memorial Volume of the *Bulletin*, published in 1897. There were 27 charter members, 4 of them members of the faculty. I think the first officers were elected that night. The Society was organized in four sections, a little later expanded to seven. Each section had its chairman, and these sections were in turn responsible for the program of one of the biweekly meetings. Professor C. L. Herrick became the first Permanent Secretary of the infant organization.

For fourteen years thereafter I was continuously a participator in the activities of the Society. As the organization owes so much to its founder, and as I was so closely associated with him in

those formative years, I think it is fitting that I say something of the work of this remarkable man. He was a truly great teacher, and one of the finest I have ever known, but I would emphasize especially his rare power of influencing young men to adopt his own point of view on life and to devote themselves to that quest for truth which was to him the great thing in life. This was an outstanding characteristic of his personality. Rarely indeed have I known a man who so powerfully impressed those with whom he came into any sort of contact with a real longing to find out new truth by their own effort. His own work as a research student was great; his work in making and training other investigators was even greater. It became a matter of great interest to me and I tried to analyze his peculiar power and learn the secret of it. One reason doubtless was the evident sincerity of his devotion to science. He loved it and believed it as a pursuit deserving the supreme attention of any man. Now, given a noble mind, longing vaguely to realize youthful dreams of mental achievement, and bring it into close daily contact with an enthusiasm so pure and unselfish as that of Professor Herrick—is it any wonder that an ambition to emulate him should grow up in that mind? I well remember one senior of quite limited ability, who was asked what he expected to do after his graduation. "Oh, I want to be what Professor Herrick is," he replied. The obvious limitations imposed by the boy's mentality made the incident humorous at the time, but it nevertheless strikingly illustrates Professor Herrick's singular power of stimulating the interest and the ambition of his students. College students are remarkably keen in detecting any failure of their instructors in zeal for the progress of their special subject, and equally responsive to any manifestation of genuine enthusiasm.

Again his extraordinary industry emphasized the effect of his sincere devotion to science. From a letter from a former student who was for a time a member of his household I read, "His tireless energy was inspiring. His light was the last to go out in the home, and early in the morning, before breakfast, we often found him returning from woods or swamp with a supply of material for the day's classes." He seemed to be driven to work by some neces-

sity of his being. Another reason for his power over his students was his subordination of lesser aims and interests to the large aim of his life. Most of us lack perspective in our outlook on life. We divide our energies among so many things that we do none of them well; nothing in our individuality stands out in such a way as to compel the interest or admiration of our acquaintances. He gave such emphasis to his scientific labors that we always thought of him as a man of science.

Another attractive and compelling quality of his was the freshness and originality of his ideas; he would take even conventional and commonplace ideas and make them fresh and new. The philosophic bearing of scientific questions interested him. Such titles among his papers as "The Psychophysical Basis of Feelings," and "Psychological Corollaries of Neurological Discoveries" illustrate this quality of his mind.

I might go on and enumerate moral as well as mental traits which drew young men after him. But not to go to too great a length, I name these things to account for the fact that the Denison Scientific Association not only became a going concern at once, but kept on growing through the following years with a healthy development. The stimulus of his exceptional personality was greatly needed—probably a necessary element of success—because there were some things in the environment that were not helpful to the new enterprise. Among other things, there was the tradition that the B.S. course of the college was inferior to the Bachelor of Arts course. It was only since 1881 that the Scientific course had been extended from three to four years, and even then—until 1886, one year before this time—the requirements for entrance to the Scientific course of the college were less exacting by one year's work than they were for classical students. This fact that the B.S. course was not so stiff in its requirements had been a detriment; it was less respected because it naturally became to a certain extent a refuge for students of the B.A. course who fell behind in their work. The presence in the B.S. classes of even a small element of this character tended to keep the better students out of the scientific course. It was still true that the phrase "gone scientific" was sometimes equivalent to "failed in Greek and Latin."

In the "Memorial Volume" of the Denison Scientific Association which appeared ten years later, the historian of the preceding decade could write "the experience of the last ten years has shown beyond doubt that the B.S. course has become more popular by being made longer and harder." But this had by no means become true in 1887. Therefore there was real need of an outstanding scientist with an exceptionally magnetic personality to give the new-born organization a chance for healthy growth in a somewhat unfavorable atmosphere. This need Prof. C. L. Herrick was able to supply and he did it wonderfully well. By the time he left the University in 1889, the development of the institution was sufficiently far advanced so that its future progress could be entrusted to less inspiring leadership. Certainly the Association was peculiarly fortunate in its founder and leader of those opening years.

We have taken a look into the somewhat remote past—the conditions surrounding the birth of this Denison Scientific Association.

Other speakers have told us much of interest in its later development and its status in recent years.

As a representative of physics, which is the most fundamental of the natural sciences, I should like now to take a look into the future, in the effort to discover what the coming task of a healthy Scientific Association should be. What kind of problems should it undertake? What is its relation to our developing civilization?

Electrons and protons form all the elements—discovered by pure research. "No field of applied science is quite so interesting and useful as that which is being found out about the electrons." Already remarkable industrial applications are being made in radio field, in broadcasting, detection, amplification; in X-rays, or some electrons, raised to speeds of thousands of miles per second by strong electric forces, penetrate atoms and send X-rays.

Radio active materials are likely to assume tremendous importance in the field of industry.

Photo-electricity gives means of sending pictures by wire and by radio. Effects can be tremendously amplified by radio-amplification methods.

The "discussion" way of seeking knowledge has changed into the "experiment" way. Harvard in this country, and the University of Cambridge in England, were primarily theological schools, but now they seek knowledge especially by observation, experience, and research.

In the near future the public speaker may do much better than speak before an audience. He will speak before an electro-physico-chemical-apparatus and revise and correct his address before presentation. The address, well preserved in the apparatus, will be presented as desired; every listener will hear as plainly and see the speaker as well as though they were face to face. Meanwhile the speaker may be enjoying a game of golf. If this had been in vogue years ago, the artificial and unconvincing presentation of the politician and the well-known pulpit voice of the preacher, might now both be unknown.

Man usually does not know what he wants until he has it. He did not plan to see his bones until the X-rays showed them to him.

As material progress goes on, manual labor becomes less and less our duty, and new possibilities of mental growth come. Evolution means less stomach and more brain, less jelly and more nerve.

Scientific processes and methods are changing the arts and industries to an extent not commonly realized.

A new discovery is made; presently a great industry suddenly springs into existance.

In Canada large quantities of low grade iron ore exist; they cannot now compete commercially with the richer ones of North Michigan; but a newly discovered process of electrical or chemical reduction of the low-grade ore may bring a new industry into being in a very short time.

The amount of time and money spent on research in pure science will probably be vastly greater in a few years than it is now.

Generous publicity is now given by the daily press to new scientific achievements. Some examples may be cited.

1. The new rayon industry is very recent, but in 1925 the production was 180 million pounds, and is increasing rapidly.

2. The new lacquers, nitro-cellulose products, which are revolutionizing the automobile industry, are a direct product of chemical research. They reduce the finishing process from days to hours.

3. The pulp and paper industries owe their extraordinary development to scientific researches.

4. The electric furnace, first developed in the laboratory, gives us aluminum kitchen ware and special alloys used in great quantity in motor cars and airplanes. It has given us also carborundum. In Norway it is responsible for thousands of tons of valuable fertilizer, the electric current coming from water power.

5. The spectacular growth of the radio industry in the last few years is familiar to all of us. Research work in pure science is responsible for its existence.

6. A familiar laboratory experiment in electrostatics has recently evolved into an industrial process by means of which many tons of valuable potash are recovered from the waste gases coming from Portland cement kilns.

7. German wood alcohol, produced by a new process worked out by specialists, is made from hydrogen and carbon monoxide and sold at a price far below that at which the same material can be produced by the older process, *viz.*, the destructive distillation of wood.

So science serves humanity!

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NOTE: In accordance with a ruling of the postal authorities it has become necessary to change the name of this publication from "BULLETIN" to "JOURNAL" of the SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY.